Specification

ROTARY DRY VACUUM PUMP

Technical field

[0001]

The present invention relates to a rotary dry vacuum pump used in an apparatus such as a semiconductor manufacturing apparatus into which reaction produced gas is poured and, in particular, to such rotary dry vacuum pump structured in such a manner that the reaction produced gas is difficult to flow into a canned motor serving as the power part of the rotary dry vacuum pump.

Background Art

[0002]

In a semiconductor manufacturing process, there is found a problem that impurities such as oil mix into a reaction chamber and thus a semiconductor is contaminated by such impurities. Especially, such problem is raised by the mixture of oil from a vacuum pump into the reaction chamber for exhausting gas existing in the reaction chamber. In view of this, conventionally, there has been used a rotary dry vacuum pump. The rotary dry vacuum pump includes a screw vacuum pump, a roots vacuum pump, a scroll vacuum pump and the like. Such rotary dry vacuum pump has a shaft for rotating a rotor and uses a bearing for supporting the shaft. Normally, lubricating oil sticks to the bearing and thus, in order to

prevent the oil component of the lubricating oil from flowing into the exhaust chamber of the rotary dry vacuum pump, there is interposed a shaft seal between the exhaust chamber and the bearing part of the vacuum pump. However, when the shaft seal is worn, there is a possibility that the oil component can flow through the shaft seal and thus can leak from the exhaust chamber of the rotary dry vacuum pump into the reaction chamber. The reason for this is that a motor for rotating the rotor exists in the open air, thereby causing a great difference between the pressure on the motor side and the pressure on the exhaust chamber side forming a vacuum. Therefore, when the shaft seal is worn and a clearance is formed in the shaft seal, the open air can leak into the exhaust chamber, causing a factor to decrease the performance of the vacuum pump. To solve this problem, in the rotary dry vacuum pump including a rotation drive part, there is used a canned motor which is capable of keeping the pressure of the interior of the motor substantially equal to that of the exhaust chamber. Referring to the structure of the canned motor, the motor includes a stator winding for generating a rotation magnetic field in a stator core, the interior of a metal-made thin cylindrical partition wall (can) mounted on the inner peripheral side of the motor is hermetically sealed by a frame, a side plate and the partition wall, and a rotary element is mounted on the shaft of the motor supported by a bearing fixed to a bracket, thereby

providing a rotatable structure. (Patent Reference 1).

Patent Reference 1: JP 2003-189529 publication

Disclosure of The Invention

Problems that The Invention is to solve

[0003]

However, when the canned motor is used in the drive part of the rotary dry vacuum pump for a semiconductor manufacturing apparatus into which the reaction produced gas is poured, the interior of the partition wall with the rotary element housed therein forms a vacuum while the canned motor is in operation. This raises a problem that, when the canned motor is stopped and thus the pressure of the interior of the partition wall returns back to the atmospheric pressure, the reaction produced gas flows and mixes from inside the exhaust chamber into the interior of the canned motor and thus reaction produced products stick to the composing parts of the canned motor disposed in the interior of the partition wall to thereby break down the canned motor. Also, in this case, when the reaction products stick to the bearing and shaft seal as well, the vacuum pump itself can be broken down.

Means for Solving the Problems

[0004]

The present invention aims at solving these problems. In particular, according to the invention as set forth in Claim 1, there is provided a rotary dry vacuum pump, comprising: one

or plural rotors housed within a housing; bearings for respectively supporting the shafts of these rotors; a suction port and an exhaust port respectively formed in the housing for sucking and exhausting fluid; and a rotary rotor composed of a motor for driving and rotating at least one of the rotors, wherein the motor includes a stator core, a partition wall mounted on the rotor inner peripheral side of the motor is fixedly secured to the housing to thereby hermetically seal the interior of the partition wall, a rotary element is rotatably disposed within the partition wall, the shaft of at least one of the rotors and the shaft of the rotary element are fixedly secured together to thereby be able to drive and rotate the rotor, and there is opened up a gas charge hole in the motor for charging purge gas into the partition wall. When the purge gas charge hole is formed in the flange of the motor, it is easy to work it. Also, the partition wall can be made of magnetic metal. And, the purge gas is also allowed to flow to the bearings respectively supporting the shafts of the rotors rotatably.

[0005]

According to the invention as set forth in Claim 2, the shaft of the motor and the shaft of the rotor are formed integral with each other. In assembling the vacuum pump, for example, after the rotor is fixed to a flange constituting the housing, the rotary element of the motor is fixed to the

shaft mounted on the end portion of the rotor by given means, this end portion is fixed to the flange through a cylindrical member constituting the partition wall, and the partition wall is then covered with the flange constituting the housing to thereby hermetically seal the interior of the partition wall. By the way, in the portions of the motor that must be hermetically sealed, there are disposed O rings.

[0006]

According to the invention as set forth in Claim 3, the motor is disposed on the suction port side. Here, to decrease the amount of leakage of the lubricating oil into the motor from the bearings interposed between the exhaust chamber and motor, there may be used grease instead of the lubricating oil. Also, when the rotary dry vacuum pump is arranged vertically and the bearings and motor are set in the upper portion of the pump, the effects of the invention can be increased further. Further, when a rotary dry vacuum pump having two or more shafts is arranged vertically, timing gears for synchronization and requiring lubricating are disposed on the lower discharge port side, and the motor is disposed on the suction side, the contamination of the exhaust chamber due to the lubricating oil can be prevented.

[0007]

According to the invention as set forth in Claim 4, flow rate control means is disposed on a pipe for sending the purge

gas to the purge gas charge hole. As the flow rate control means, there are available means for throttling the flow rate of the purge gas through a purge gas flow hole of a given size opened up in a purge gas flow passage and, as the need arises, a hand-operated valve; and further, there is disposed an electromagnetic valve on the N2 supply side. When the pump is caused to stop, or before or after the pump is caused to stop, and while the pump is running, if the flow rate of the gas varies, especially if the gas flow rate increases and thus the pressure of the interior of the exhaust chamber exceeds the pressure of the interior of the partition wall of the motor, the electromagnetic valve is opened to thereby allow the gas to flow in an amount controlled by the valve as the purge gas, thereby being able to prevent the process gas from flowing into the bearing part and motor part of the vacuum pump.

By the way, if the flow rate of the gas is determined, instead of the valve, there may be formed in the pipe an orifice which is capable of pouring the same amount of gas therethrough. In this case, the control valve can be omitted.

Also, when controlling the flow-in amount of the gas, the amount can be controlled at the time when the electromagnetic valve is opened, or there can be used an electromagnetic valve having a flow rate control function.

[0008]

According to the invention as set forth in Claim 5, there

are arranged a pressure measuring device for measuring the pressure of the interior of the partition wall and/or a pressure measuring device for measuring the pressure of the interior of an exhaust chamber. By finding a difference between the two pressures, the gas flow rate may be controlled using the electromagnetic valve such that the pressure of the interior of the partition wall is equal to or larger than the pressure of the interior of the exhaust chamber. Also, the flow-in amount of the purge gas as well as the flow rate thereof can also be controlled using only one of the two pressures. As the pressure measuring device, there is available a thin film semiconductor detector or the like. Also, by measuring the pressure of the interior of the chamber of a semiconductor manufacturing apparatus or the like in which the gas is exhausted using a vacuum pump, the flow-in amount and flow rate of the purge gas can also be adjusted. The flow-in amount and flow rate of the purge gas may also be adjusted using only variations in the pressure of the interior of the chamber, or they may be controlled according to the pressure of the interior of the partition wall.

[0009]

According to the invention as set forth in Claim 6, there is further provided rotation number measuring means for measuring the number of rotations of the rotary element of the motor and the rotors. In the present rotation number measuring

means, an encoder may be mounted on the rotary element of the motor and the magnetism of a permanent magnet provided in the rotary element may be detected at a specific position by the encoder to thereby find the number of rotations of the rotary element. The flow-in amount and flow rate of the purge gas are controlled in accordance with the thus found number of rotations. For example, when the number of rotations decreases, the control to allow the flow of the purge gas is made, or, according to the increase or decrease ratio of the number of rotations, the flow-in amount and flow rate of the gas can be adjusted.

[0010]

According to the invention as set forth in Claim 7, there is disposed means for measuring the power consumption of the motor. The flow rate of the gas can be adjusted depending on the power consumption of the motor measure by this means. For example, when the power consumption is varied due to an increase in the suction gas amount during the running operation of the motor, the control to allow the flow of the purge gas can be made, or, at the time when the motor is not running, the flow-in amount and flow rate of the purge gas can be adjusted according to the variations in the power consumption.

[0011]

According to the invention as set forth in Claim 8, there is provided a reaction produced gas flow meter in the vicinity

of the suction port or exhaust port. In this case, the flow rate of the purge gas can be controlled according to variations in the flow rate of the reaction produced gas. For example, when the flow rate of the reaction produced gas increases, the control to increase the flow rate of the purge gas may be made. Also, the flow rate of the purge gas may also be adjusted according to the flow rate of the gas that is charged into the above-mentioned chamber.

Advantages of the Invention

[0012]

According to the invention as set forth in Claim 1, in a rotary dry vacuum pump, comprising: one or plural rotors housed within a housing; bearings for supporting respectively the shafts of these rotors; a suction port and a discharge port respectively formed in the housing for sucking and discharging fluid; and a rotary rotor composed of a motor for driving and rotating at least one of the rotors, the motor includes a stator core fixed to the interior of the housing of the motor, a partition wall mounted on the rotor inner peripheral side of the motor is fixedly secured to the housing to thereby hermetically seal the interior of the partition wall, a rotary element is fixed to the shaft within the partition wall to thereby provide a rotatable structure, and there is opened up a gas charge hole in the motor for charging purge gas into the partition wall. Thanks to this, when the pump is caused to

stop and thus the pressures of the vacuum exhaust chamber and the interior of the partition wall return back to the atmospheric pressure, in order to prevent the reaction produced gas within the vacuum exhaust chamber from leaking into the interior of the partition wall from the exhaust chamber and thus to prevent such accumulation of the products in the motor composing parts such as the rotary element that can break down the motor, the purge gas may be charged into the motor; that is, this can prevent the reaction produced gas from flowing from the vacuum exhaust chamber into the interior of the partition wall. Also, by applying the purge gas to the bearings similarly, the reaction products can be prevented from sticking to the bearings, thereby being able to prevent the bearings from being broken down due to the reaction products.

[0013]

According to the invention as set forth in Claim 2, since the shaft of the motor and the shaft of the rotor are formed as an integral body, not only the connecting part for connecting the two shafts together can be omitted but also there can be eliminated the need to align the two shafts with each other.

[0014]

According to the invention as set forth in Claim 3, because of employment of a structure in which the motor is disposed on the suction port side, normally, in order to prevent the interior of the exhaust chamber from being contaminated

by oil, the portions of the pump requiring lubricating oil are disposed on the discharge port side. Thus, by arranging the motor on the suction port side in which the lubricating oil is not used so much, the flow of the lubricating oil into the interior of the partition wall can be restricted to a minimum.

[0015]

According to the invention as set forth in Claim 4, in a pipe used to send the purge gas to the purge gas charge port, there is provided flow rate control means. Thanks to this structure, a minimum quantity of purge gas necessary to prevent the process gas from flowing into the interior of the partition wall during the stop of the pump can be poured. Therefore, the wasteful use of N2 can be restricted and the spread of the lubricant sticking to the bearing part to the exhaust chamber can be minimized.

[0016]

According to the invention as set forth in Claim 5, there are further provided a pressure measuring device for measuring the pressure of the interior of the partition wall and/or a pressure measuring device for measuring the pressure of the interior of the exhaust chamber. Thanks to this structure, the flow rate of the purge gas can be controlled using an electromagnetic valve or the like in such a manner that the pressure of the interior of the partition wall is slightly higher than that of the interior of the exhaust chamber.

[0017]

According to the invention as set forth in Claim 6, because of provision of measuring means for measuring the number of rotations of the rotary element of the motor or the rotors, such control as to pour only the necessary purge gas is possible. This can eliminate not only the wasteful use of gas but also a problem that the purge gas can leak into the exhaust chamber to thereby decrease the exhaust performance of the pump.

[0018]

According to the invention as set forth in Claim 7, owing to provision of means for measuring the power consumption of the motor, it is possible to realize the control for pouring only the necessary gas, which not only can avoid the wasteful use of gas but also can prevent the purge gas from leaking into the exhaust chamber and thus can prevent the worsened exhaust performance of the pump.

[0019]

According to the invention as set forth in Claim 8, in the vicinity of the suction port or exhaust port, there is provided a gas flow meter. This makes it possible to realize the control that allows the flow of only the necessary purge gas. Thanks to this, not only the wasteful use of gas can be avoided but also the leakage of the purge gas into the exhaust chamber and thus the lowered exhaust performance of the pump

can be prevented.

Best Mode for Carrying Out the Invention

[0020]

In Fig. 1, as an embodiment of a rotary dry vacuum pump according to the invention, there is shown a screw vacuum pump.

[0021]

The vacuum pump 200 comprises two screw rotors 202 and 204.

The screw rotors 202 and 204 are housed in the interior of a housing 210. In detail, the screw rotor 202 is rotatably supported in the housing 210 by bearings 231 and 233, whereas the screw rotor 204 is rotatably supported in the housing 210 by bearings 234 and 236. Also, timing gears 251 and 253, a motor 241, and seals 237, 238, 239 and 240 are arranged as shown in Fig. 1. Here, the seals 237 and 238 separate the bearings 231 and 233 from a screw rotor storage chamber 210b, whereby not only the lubricating oil of the bearings 231 and 233 is prevented from leaking into the screw rotor chamber 210b but also a foreign substance is prevented from entering the bearings 231 and 233 from the screw rotor storage chamber 210b. Similarly, the seals 239 and 240 separate the bearings 234 and 236 from the screw rotor storage chamber 210b, thereby not only preventing the lubricating oil of the bearings 234 and 236 from leaking into the screw rotor storage chamber 210b but also preventing a foreign substance from entering the bearings 234

and 236 from the screw rotor storage chamber 210b. By the way, as the seals 237, 238, 239 and 240, there are available a contact type seal, a clearance seal such as a magnetic fluid seal and a Labyrinth seal, and other type seal.

[0022]

Also, to one-end portions of the screw rotors 202 and 204, there are fixed timing gears 251 and 253 which can rotate the screw rotor 202 as the screw rotor 204 is rotated, while the timing gears are meshingly engaged with each other. Further, to the other end portion of the screw rotor 202, there is connected the motor 241 integrally therewith.

[0023]

The screw rotor storage chamber 210b is allowed to communicate with the outside of the housing 210 through a suction port (not shown) which is formed in the wall portion of the housing 210 and is used to suck compressible fluid into the inside of the housing 210 from the outside of the housing 210; and, the screw rotor storage chamber 210b is also allowed to communicate with the outside of the housing 210 through a discharge port (not shown) formed in the wall portion of the housing 210 to discharge the compressible fluid from the inside of the housing 210 to the outside of the housing 210. Here, the suction port is in communication with a vessel to be evacuated (not shown), whereas the discharge port is in communication with an exhaust gas processing device (not

shown).

[0024]

The housing 210 is composed of a first housing member 211, a second housing member 212, a third housing member 213, a fourth housing member 214 and a fifth housing member 215. Here, the first housing member 211 constitutes a suction side flange and also serves as the housing of the canned motor 241. The second, third and fourth housing members 212, 213 and 214 cooperate together in constituting a housing main body; and also, these housing members 212, 213 and 214 cooperate together in defining a vacuum exhaust chamber. To the second housing member 212, there are fixed the bearings 231, 234 and the shaft seals 237, 239. Also, to the fourth housing member 214, there are fixed the bearings 233, 236 and the shaft seals 238, 240.

[0025]

Next, description will be given below of the structure of the canned motor 241 which is the drive part of the vacuum pump 200 according to the present embodiment. The canned motor 241 includes a stator winding which is used to generate a rotation field in a stator core 261. On the stator inner peripheral side of the canned motor, a rotary element 265 is fixed to the shaft portion 263 of the canned motor 241 which is formed integral with the rotor 202. The stator core 261 and rotary element 265 are separated by a partition wall (can) 281, while the partition wall 281 is closely contacted with

and fixed to the second housing member 212. The flange 267 of the canned motor 241 is closely contacted with and fixed to the partition wall 281, so that the rotary element 265 can be sealed from the open air. In the flange 267, there is opened up a charge hole 269 which is used to charge purge gas (for example, nitrogen gas or argon gas) into the inside of the canned motor 241 hermetically sealed by the partition wall 281, housing second member 212 and flange 267 with their connecting portions hermetically closed by O rings (not shown) or the like. In the charge hole 269, there is mounted a flow passage 271 which is used to guide the purge gas; and, on the flow passage 271, there are mounted flow rate control means (for example, a hand-operated valve and an orifice) 273 and an electromagnetic valve 275 which are used to control the flow rate of the purge gas.

[0026]

Next, description will be given below of the operation of the vacuum pump 200 according to the present embodiment.

Firstly, when the canned motor 241 rotates the screw rotor 202, with the rotation of the screw rotor 202, the screw rotor 204 is rotated because the timing gears 253 and 251 are fixed to the one-end portions of the screw rotor 204 and screw rotor 202 in a mutually meshing manner. When the screw rotor 202 and screw rotor 204 are rotated, compressible fluid existing in the interior of the screw rotor storage chamber

210b is moved from the suction port side to the communication passage 210c side and is then discharged out through the communication passage 210c. Also, when the compressible fluid within the screw rotor storage chamber 201b is discharged out of the screw rotor storage chamber 210b through the communication passage 210c, new compressible fluid is sucked from the vessel to be evacuated into the screw rotor storage chamber 210b through the suction port.

At the then time, the interior of the canned motor 241 hermetically sealed by the first housing member 211, second housing member 212 and flange 267 forms a vacuum.

Therefore, when the vacuum pump is brought to a stop, the pressure of the interior of the exhaust chamber 210c rises and thus gas existing in the exhaust chamber 210c reverse flows into the interior of the canned motor 241 hermetically sealed by the first housing member 211, second housing member 212 and flange 267 the pressure of which are low. In cases where the gas within the exhaust chamber is corrosive gas or reaction produced gas, the gas can corrode the rotary element 265 and shaft 263, and a reaction product can stick to them to thereby cause the canned motor 241 to break down. Therefore, when the corrosive gas or reaction produced gas is allowed to flow, the purge gas must be poured in such a manner that the pressure of the interior of the canned motor 241 hermetically sealed by the first housing member 211, second housing member 212 and

flange 267 becomes higher than the pressure of the interior of the exhaust chamber 210c. Thus, when the pressure of the interior of the canned motor is expressed as a pressure P1 and the pressure of the interior of the exhaust chamber 210c nearest to the canned motor 241 is expressed as a pressure P2, the flow rate of the purge gas may preferably be set such that the relationship $P1 \geq P2$ can be obtained after stop of the vacuum pump. As the operation sequence of the purge gas, at the time when the vacuum pump is stopped, or before or after the vacuum pump is stopped, the electromagnetic valve may be opened and gas of a flow rate L controlled by a valve (a hand-operated valve, an electromagnetic valve or an orifice) may be poured as purge gas, thereby being able to prevent the process gas from flowing into the bearing part and motor portion of the vacuum pump. If the time T necessary for the P1 to reach the atmospheric pressure is previously measured, only during the time T, the electromagnetic valve may be opened, thereby being able to pour the purge gas of the flow rate L.

Therefore, according to the present embodiment, a necessary and minimum flow rate of purge gas can be poured, so that not only the wasteful use of the purge gas can be prevented but also the spread of the lubricant sticking to the bearing part to the exhaust chamber can be minimized.

[0027]

Also, there may be used another method in which the

pressure P1 of the interior of the canned motor 241 hermetically sealed by the first housing member 211, second housing member 212 and flange 267 is measured by a pressure gauge, the pressure P2 of the interior of the exhaust chamber 210c is measured by a pressure gauge, and the flow rate of the purge gas is controlled by an electromagnetic valve in such a manner that a difference between the pressures is $P1 \geq P2$. (In this method, instead of the combination of [valve + electromagnetic valve], there is used an electromagnetic valve which can control the flow rate of the purge gas freely.) Control of the flow rate of the purge gas is not limited to the time of stop of the vacuum pump, but, during the running time of the vacuum pump as well, the purge gas may be allowed to continue to flow in a small quantity in such a manner that the relationship $P1 \geq P2$ can be obtained. Further, during the running time of the vacuum pump as well, when the flow rate of the reaction produced gas varies, there is a possibility that the pressure of the interior of the exhaust chamber can vary. Therefore, in this case, the flow rate of the purge gas should be controlled so as to be able to obtain the relationship $P1 \geq P2$.

Also, the pressure of the interior of the exhaust chamber can also be replaced with the pressure of the interior of the chamber of a semiconductor manufacturing apparatus which uses the vacuum pump according to the present embodiment.

In the present embodiment, the flow rate of the purge

gas is controlled by comparing the two pressures with each other; however, the flow rate can also be controlled by using one of the pressure of the interior of the motor partition wall, the pressure of the interior of the exhaust chamber and the pressure of the interior of the reaction chamber.

[0028]

According to the present embodiment, the flow rate of the purge gas is controlled by measuring the pressures. However, the purge gas flow rate can also be controlled by measuring the number of rotations of the motor or rotor, the power consumption of the motor and the flow rate of the reaction produced gas.

Also, in the present embodiment, there is shown only the purge gas to be poured into the motor. But, if the purge gas is also allowed to flow in the bearings, there can be prevented the occurrence of a problem that the reaction products stick to the bearings to thereby break down the rotary dry vacuum pump.

[0029]

Generally, a semiconductor manufacturing apparatus dislikes contamination by oil. In the present embodiment, there is used a vertical vacuum pump: in particular, the suction port is disposed at an upper position, the discharge port is disposed at a lower position, the portions of the timing gears always requiring lubricating oil are disposed at lower

positions, and the canned motor 241 not using the lubricating oil and disliking contamination by the lubricating oil is disposed on the suction side of the vacuum pump. This structure can restrict the contamination of the suction side with oil as much as possible. Also, use of grease for a vacuum as the lubricant of the bearings on the suction side can increase the above effect still further.

[0030]

In the present embodiment, description has been given heretofore of a screw vacuum pump of a capacity transfer type. However, the invention can also apply to a claw vacuum pump, a roots vacuum pump, a scroll vacuum pump and other type vacuum pump in which a shaft can be driven by a motor.

Also, the rotary dry vacuum pump according to the invention can have the same structure as those of the respective pumps of a plural stage type vacuum pump, for example, a two-stage screw vacuum pump.

The pressure, gas flow rate, power consumption and the number of rotations are converted to data electric signals and are transmitted to signal process means, the flow rate of the purge gas is decided by the signal process means from the data electric signals, the thus-decided flow rate is converted to an output electric signal and is transmitted to flow rate control means, and the flow rate of the purge gas is controlled by an electromagnet valve or the like.

Industrial Applicability of the Invention

[0031]

The invention can apply to a vacuum pump which includes a shaft and a motor for driving the shaft and is used to pour and exhaust an extremely small amount of reaction produced gas in a semiconductor manufacturing apparatus or the like.

Brief Description of the Drawings

[0032]

[Fig. 1] It is an axial section view of a screw vacuum pump according to the invention.

Description of Reference Numerals and Signals

[0033]

200: Vacuum pump

202, 204: Screw rotor

210: Housing

210b: Screw rotor storage chamber

231, 233, 234, 236: Bearing

251, 253: Timing gear

237, 238, 239, 240: Shaft seal

241: Canned motor

261: Stator core

263: Shaft portion

265: Rotary element

267: Flange

269: Charge hole

271: Flow passage